Dispatches

Avian Cognition: Understanding Tool Use

Although rooks are considered non-tool-using animals, a recent study has shown that they learn to solve a 'trap-tube' task faster than many tool-using primates, raising questions about the evolution of sophisticated physical cognition.

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Ever since we discovered that *Homo sapiens* is not, as we once fondly imagined, the only tool user in the animal kingdom, we have been fascinated by animal tool use. There has been an intense debate between those who believe that animals do not understand the physical principles and causal regularities that underlie tool use as we do, and those who believe that the difference is a quantitative, rather than a qualitative one (an idea expressed by Darwin as 'mental continuity' between humans and 'higher animals' [1]). Certainly, no non-human animal uses tools which have anything like the complexity and variety of those employed by modern humans. On the other hand, do we humans always understand the principles behind the operation of the tools that we use? And is an understanding of the physical domain and of causality an adaptation specific to tool users, or might the behavioural flexibility that it brings also endow non-tool users with selective advantages?

The 'trap-tube' task [2] has been a popular and useful assay of the extent of physical cognition — specifically, an understanding of the operation of gravity — in both humans and non-human animals. The principle behind the test is simple: food or another desirable item is placed inside a horizontal tube which has a vertical, blind-ended tube attached to it. Subjects must push (or pull) the item from the appropriate end of the tube using a stick, so that they do not lose the item in the trap. Subjects are assessed on how quickly they learn to avoid the trap, but the critical test involves inverting the tube so that the trap is now on the top, and seeing if subjects now disregard the position of the trap when choosing an action. The rationale is that, if they understand that unsupported items fall under gravity, they will also understand that an inverted trap cannot endanger the item.

Figure 1. The modified trap-tube task.

From this position, the rook must pull the stick to make the food drop out of the non-functional trap on the right of the photograph, rather than be trapped in the functional trap on the left.

But this design has a number of conceptual flaws [3]. As there is no penalty for continuing to use the rules that were successful during training, there is no incentive to alter the behaviour, though this does not mean that the subjects have not understood the task. Similarly, animals might pass the test without understanding the action of gravity if the visual differences between the normal and inverted tubes mean that they regard them as entirely different tasks. Furthermore, many animals have performed rather poorly on the task [2], and even humans fail to respond randomly when the trap is inverted under a variety of conditions [3], suggesting that there are methodological problems with the test. Thus, as they report this issue of *Current Biology*, Seed *et al.* [4] re-designed the experiment so that the critical test was a transfer task rather than a test in which a null response was critical (see Figure 1).

Seed *et al.* [4] and Tebbich *et al.* [5] found that non-tool-using rooks (*Corvus frugilegus*) learned the modified task in fewer trials than many of the other species which have been tested. Furthermore, all seven of the rooks passed the transfer test, in which some of the stimuli changed, and one bird passed two further transfer tests in which there were no shared visual stimuli with the training tasks [4]. This tentatively suggests the possibility that at least one rook was able to extract some causal regularities — rather than perceptual similarities — from the apparatus to solve the task. But what exactly did this rook understand? Did she understand that unsupported objects fall under gravity, or that objects can be moved smoothly along a continuous path? Whatever the nature of this understanding, there seem to be large individual variations, because only three of seven rooks in Tebbich *et al.* [5] solved the training task, and none passed the transfer task.

There has been a tendency to try to fit animals' cognitive abilities into one of two categories: either they exhibit abilities equivalent (or nearly so) to those of humans, or their abilities are based on associative learning, and are therefore somewhat inflexibly tied to the specific stimuli used during training. The real situation is likely to be much more complicated than this, and the details of what is and what is not understood, and how those differ between species and between tasks are fascinating. The striking inter-individual differences [4,5] also suggest that genetic or developmental conditions might also play an important role in determining the details of adult cognitive abilities.

But how is information about physical causality acquired? The causal structure of the world cannot be perceived directly — you cannot 'see' gravity — and must be inferred from the spatio-temporal relationships between objects. One suggestion is that natural selection has equipped some species with a theory-generating mechanism which uses the conditional probabilities between causes and outcomes to assign causality [6]. For example, if X and Y together are always followed by event Z, but Y alone is not followed by Z, X must be the cause of Z. Non-human animals can make some of these inferences through associative learning [7], and there is evidence that even very young children are capable of quite complex and subtle forms this kind of reasoning [8]. Furthermore, work by Schultz and Gopnik [9] has suggested that young children perform interventions or experiments when investigating the cause of an event, in order to falsify hypotheses about causes.

There is, however, another possibility; not all causes are equally plausible as explanations of outcomes, because of the constraints of the physical world. Animals with certain expectations about the way that the world works would be able to narrow the field of candidate causes substantially, because some causes are simply 'impossible'. We know, for example, that very young children understand that solid objects will not pass through solid barriers [10]. Knowledge about rigid objects would allow an organism to predict that, if it moved the nearest side of an object, the far side would move away an equal distance. By violating these putative expectations, and observing what animals anticipate happening, we can explore what those expectations might be.

The experiments reported by Seed *et al.* [4] also point out the importance of designing ethologically valid tasks when investigating cognitive capabilities. In this case, the fact that the animal is able to pull the food towards itself seems to enable it to perform at a much higher level, perhaps because each stage of the action brings the food closer rather than pushing it further away. Also, details of exactly what animals can and cannot do are more illuminating than the presence or absence of a particular response. The world is a bewilderingly complex place for young organisms, and we need to think much more about the ways in which information about the physical world is structured and acquired.

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Polyploid Hybrids: Multiple Origins of a Treefrog Species

***Hyla versicolor*, a tetraploid treefrog, is reported to have originated via multiple hybridization events involving three diploid ancestors. Its complex reticulate history provides insights into the roles that polyploidy and hybridization can play in the origin of species.**

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The roles that polyploidy and hybridization play in the origin of plant and animal species have been discussed for many years. The two processes often occur together in the form of allopolyploids — hybrids with two or more copies of each parental genome — but each process can be viewed separately, because many polyploids are not hybrids and vice versa. The appearance of polyploids, a form of instantaneous speciation, is common in seed plants and ferns [1]. Nevertheless, Stebbins [2] argued that polyploidy